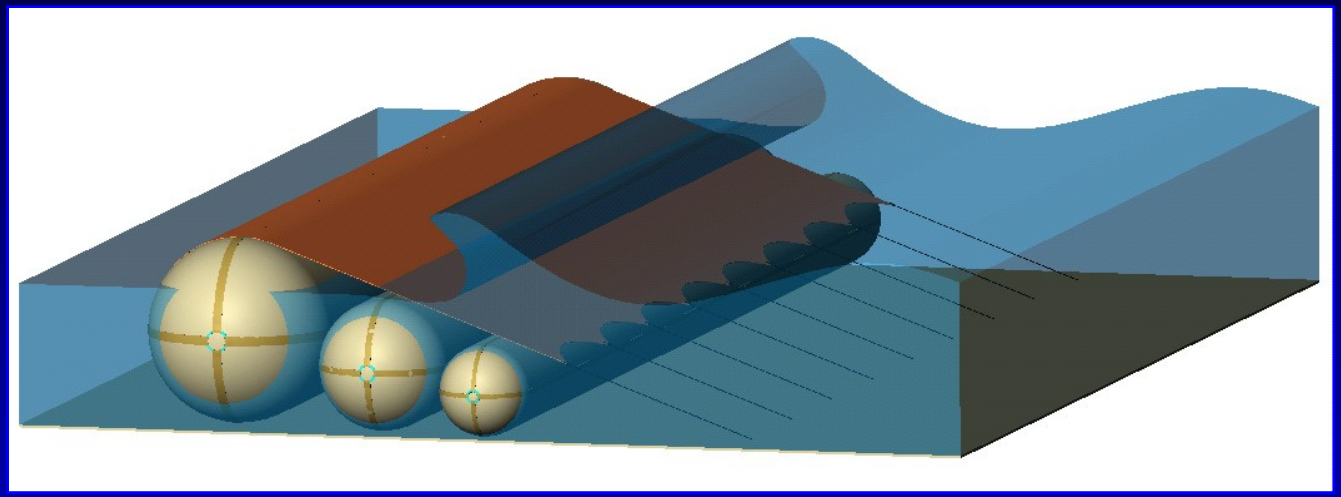
Nearshore Breakwater System



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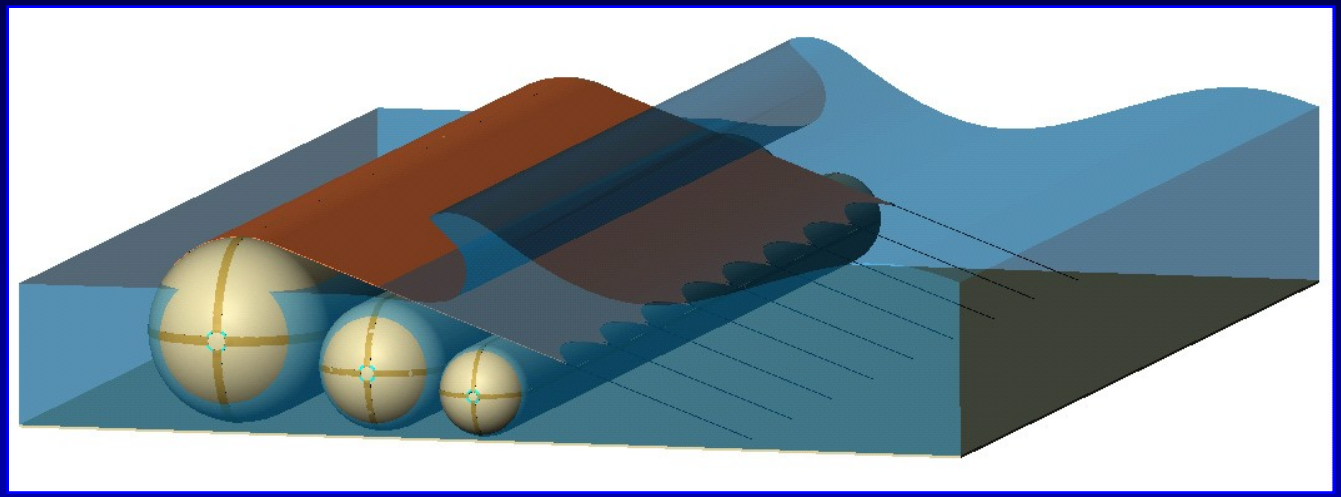
RPE Need

- Nearshore JLOTS cease in sea state 3
- Existing small ports may not have adequate draft
- Existing ports are relatively easily denied
- Need calm water for nearshore JLOTS operations
- No rapidly installable technology exists
  - Traditional breakwaters and piers require months to construct or repair
  - Floating causeways are not functional in and above SS3 and do not work nearshore
  - Huge breaking wave forces in nearshore zone demand a rational engineering approach for both mooring and structural integrity

NBS R&D Program

- **Operating metrics**
  - Deploy in SS3, Operate in SS1-SS5
  - Deploy in 2-3 days
  - Operate in depths of 0 - 30 ft
  - Reduce wave heights by 50%
- **Identify promising ideas**
  - Physical modeling
  - Numerical modeling
- **Full scale testing**

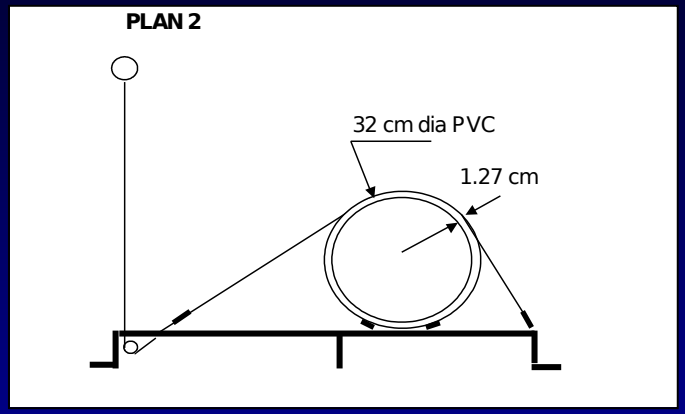
NBS Primary Concept

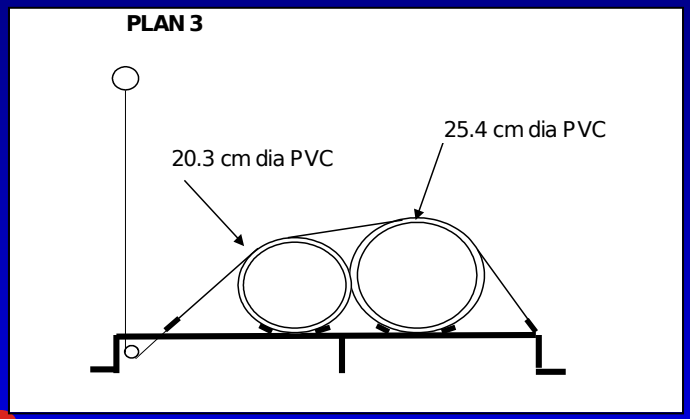


Physical Model Study

- Conducted 1:20 scale model of fabric tube structure
- Wave flume 3’ x 3’ x 148’
- Scaled irregular wave climate
- Included sand bed
- Roughly scaled fabric elasticity

Model Structures

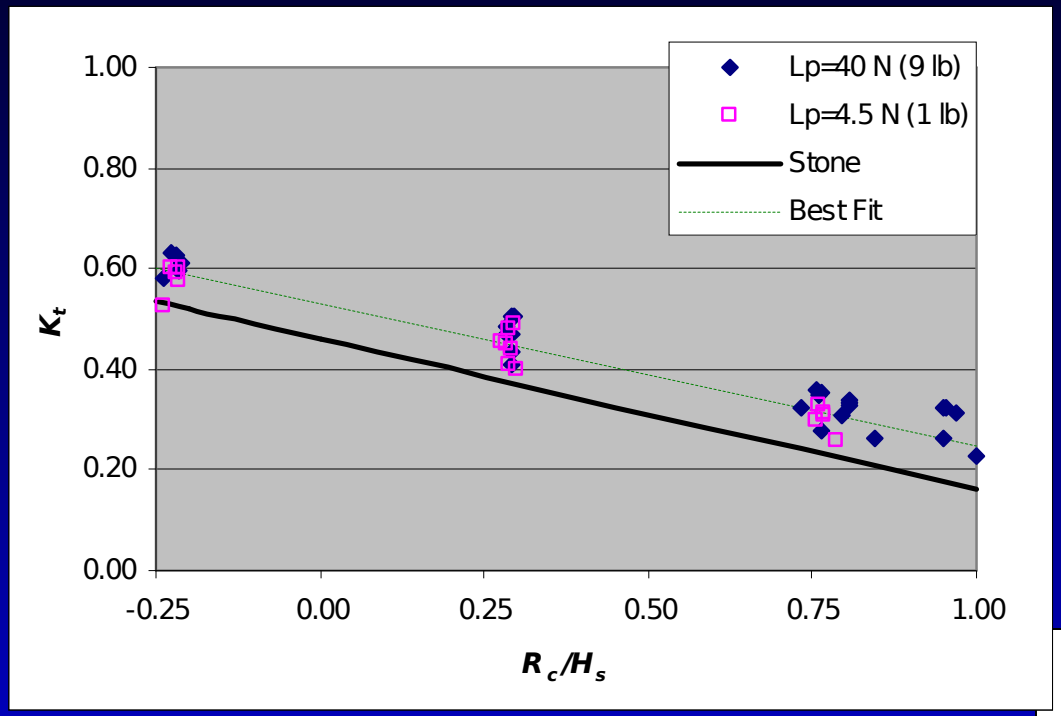




Physical Model Study

- Measurements
  - Incident and transmitted waves
  - Displacement of tubes
  - Forces on fabric
  - Sediment scour

Wave Overtopping

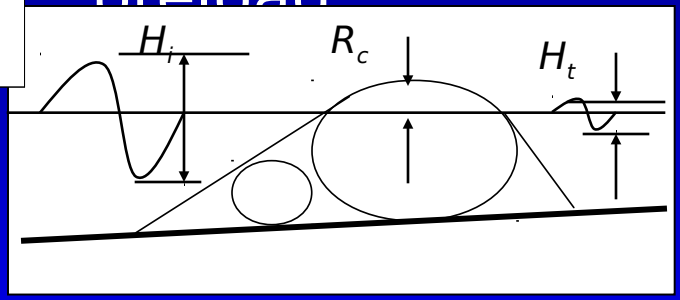


$K_t = H_t/H_i$

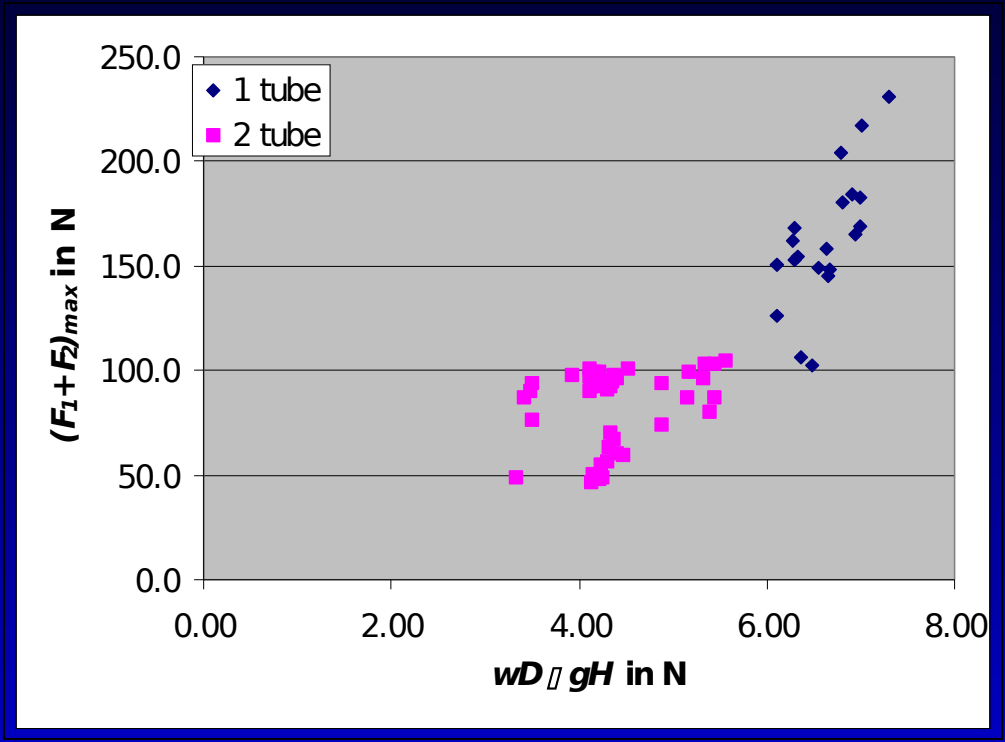
R_c = freeboard

H_s = wave height

L_p = fabric preload



Wave Forces in Fabric



Conversion: 4.45 N/lb

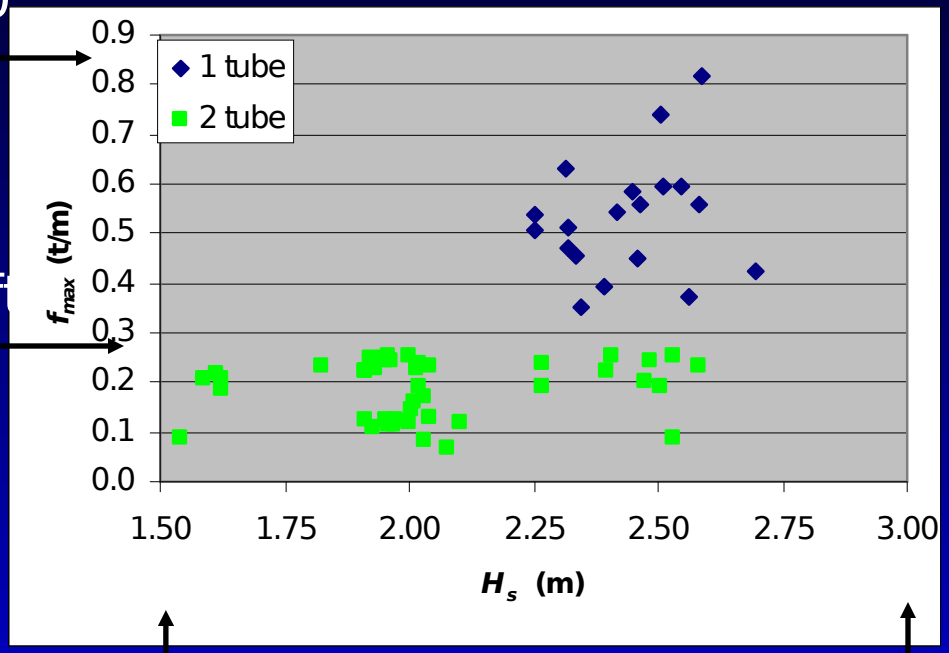
Maximum Full-Scale Force

F_{max} = 13.7 t/50 ft

for single tube

F_{max} = 4.6 t/50 ft

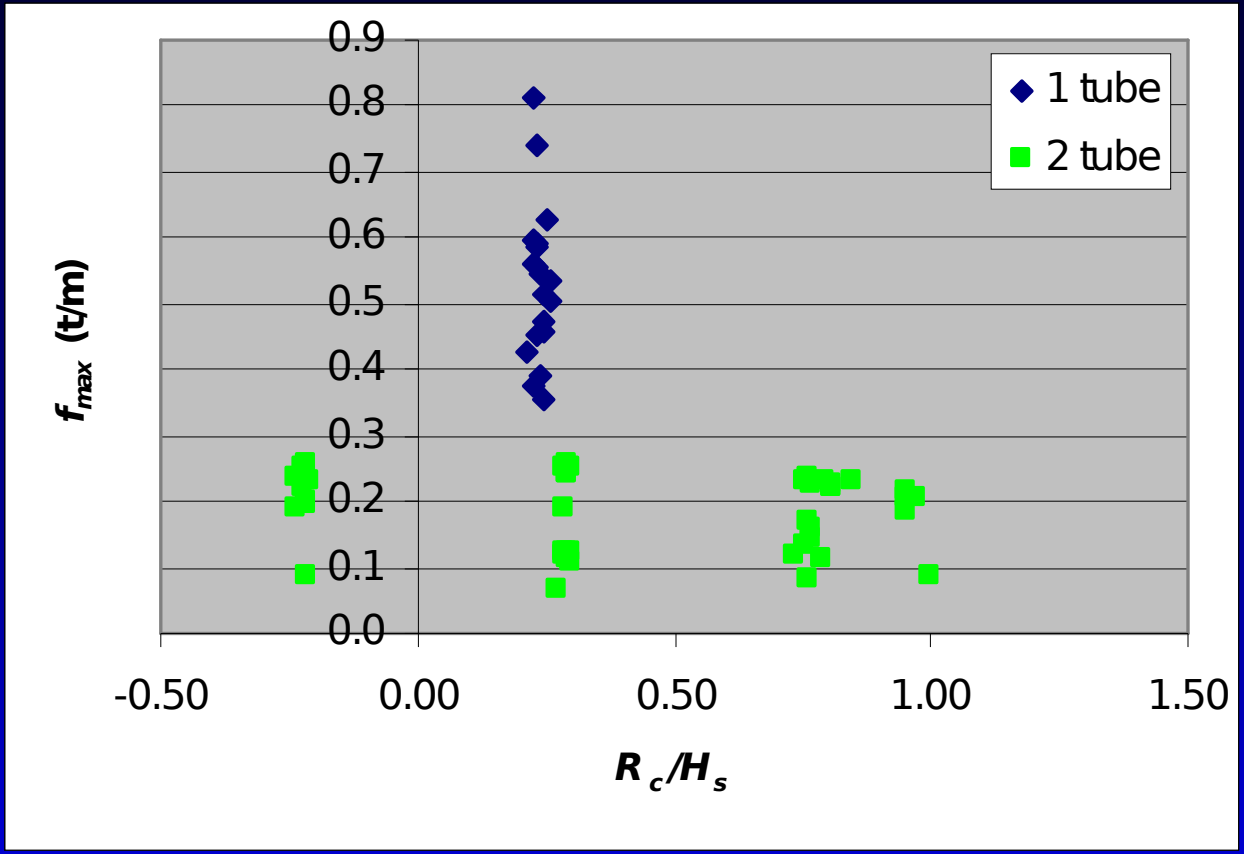
for two-tube



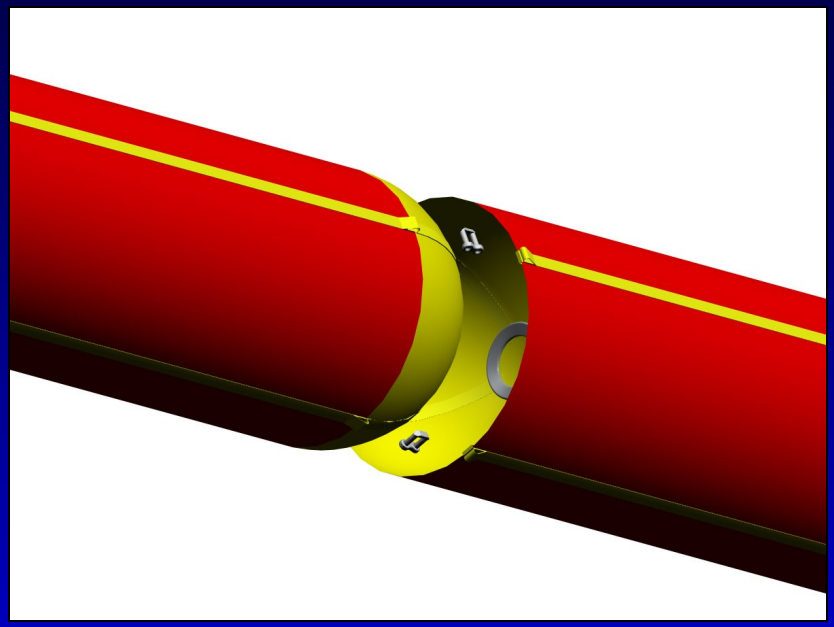
H_s = 5 ft

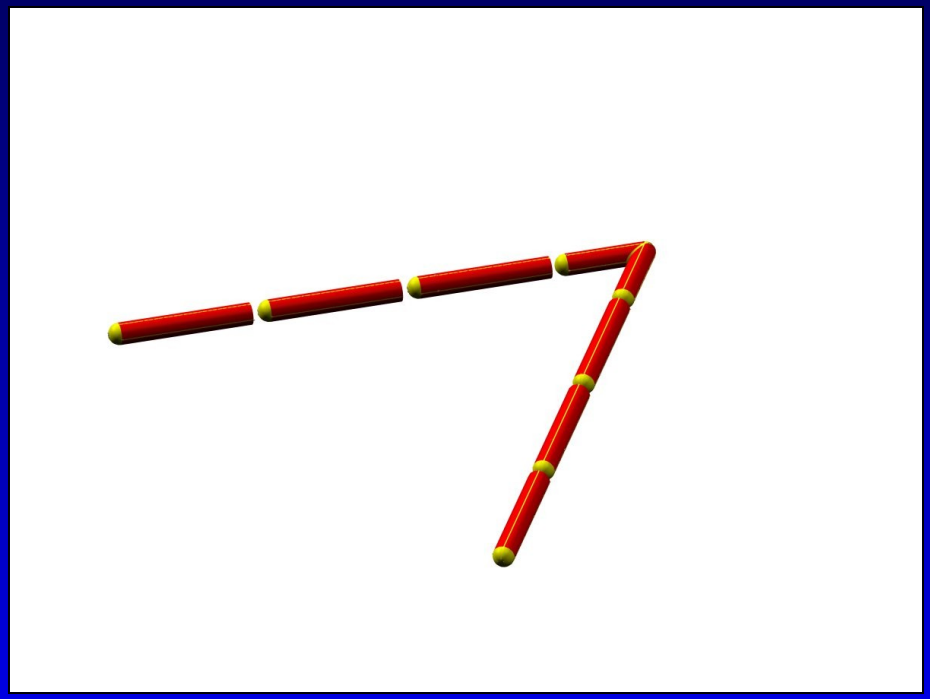
H_s = 10 ft

Maximum Full-Scale Force



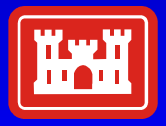
Fabric Tube Connection Transfers Moment





Numerical Modeling

- Navier-Stokes Solver
- Full solution of non-linear fundamental hydrodynamic equations with turbulence using finite elements
- Very efficient mesh handling algorithms
- Very large scale grids - O(10 M nodes)
- Can be used as rapid prototyping tool for NBS



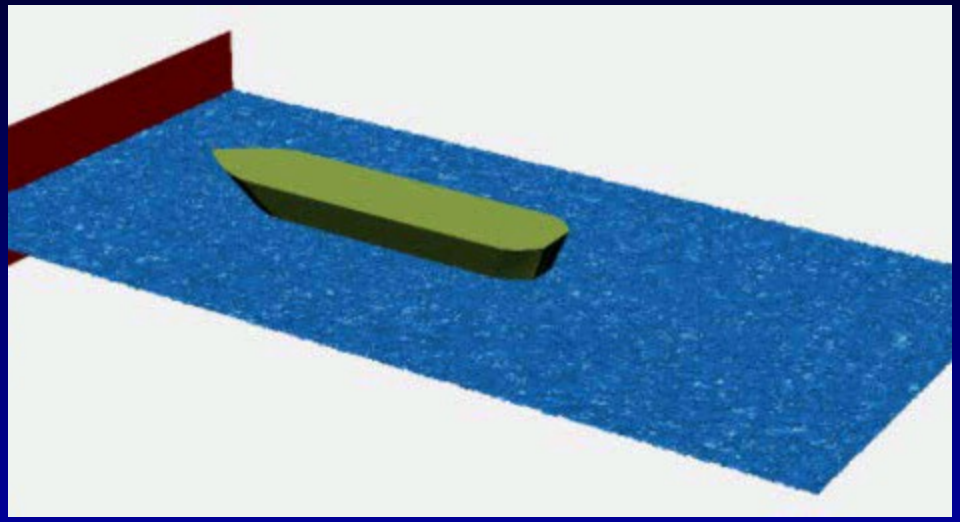
Navier-Stokes Solver

$$\rho\left(\frac{\partial \mathbf{u}}{\partial t} + \mathbf{u}\cdot\nabla\mathbf{u} - \mathbf{g}\right) - \nabla\cdot\boldsymbol{\sigma} = 0$$

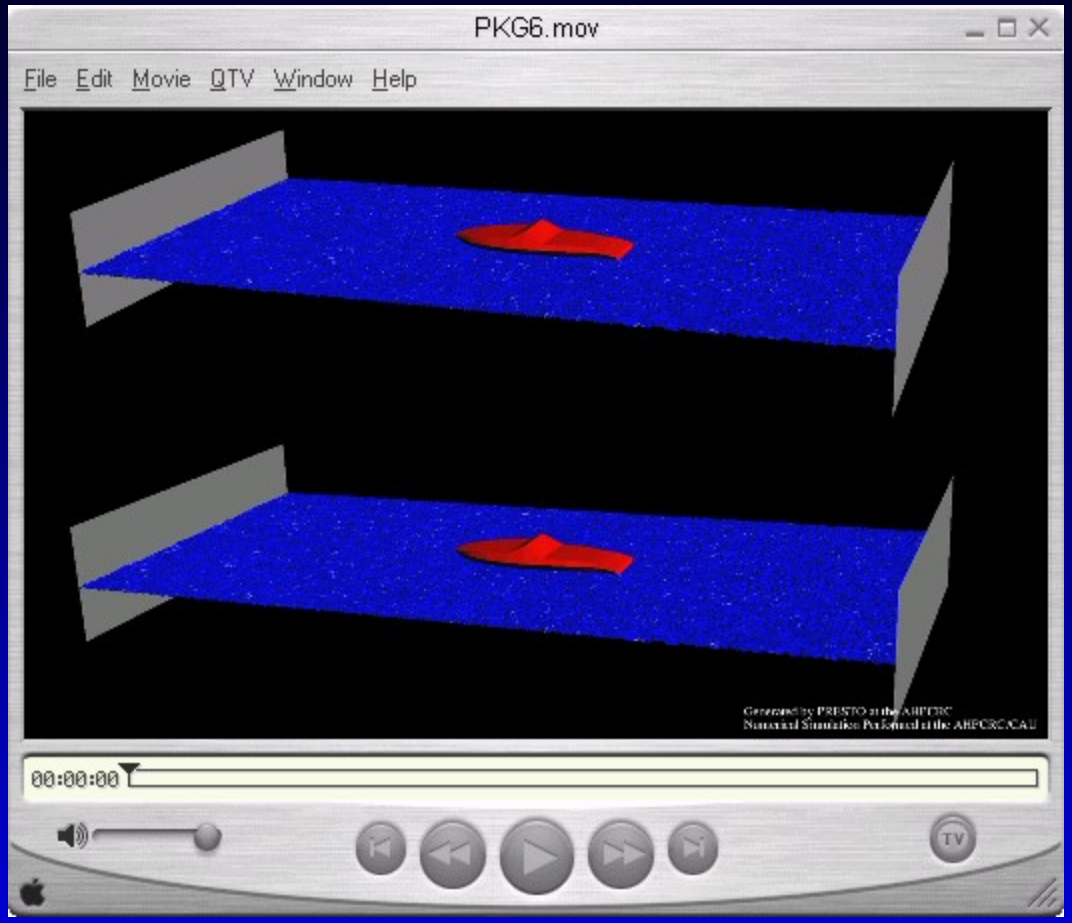
$$\nabla\cdot\mathbf{u} = 0 \qquad \boldsymbol{\sigma} = -p\mathbf{I} + 2\mu\boldsymbol{\varepsilon}(u) \qquad \boldsymbol{\varepsilon} = \frac{1}{2}\left(\nabla\mathbf{u} + \nabla\mathbf{u}^{\mathrm{T}}\right)$$

Solved using a finite element formulation with free surface tracking

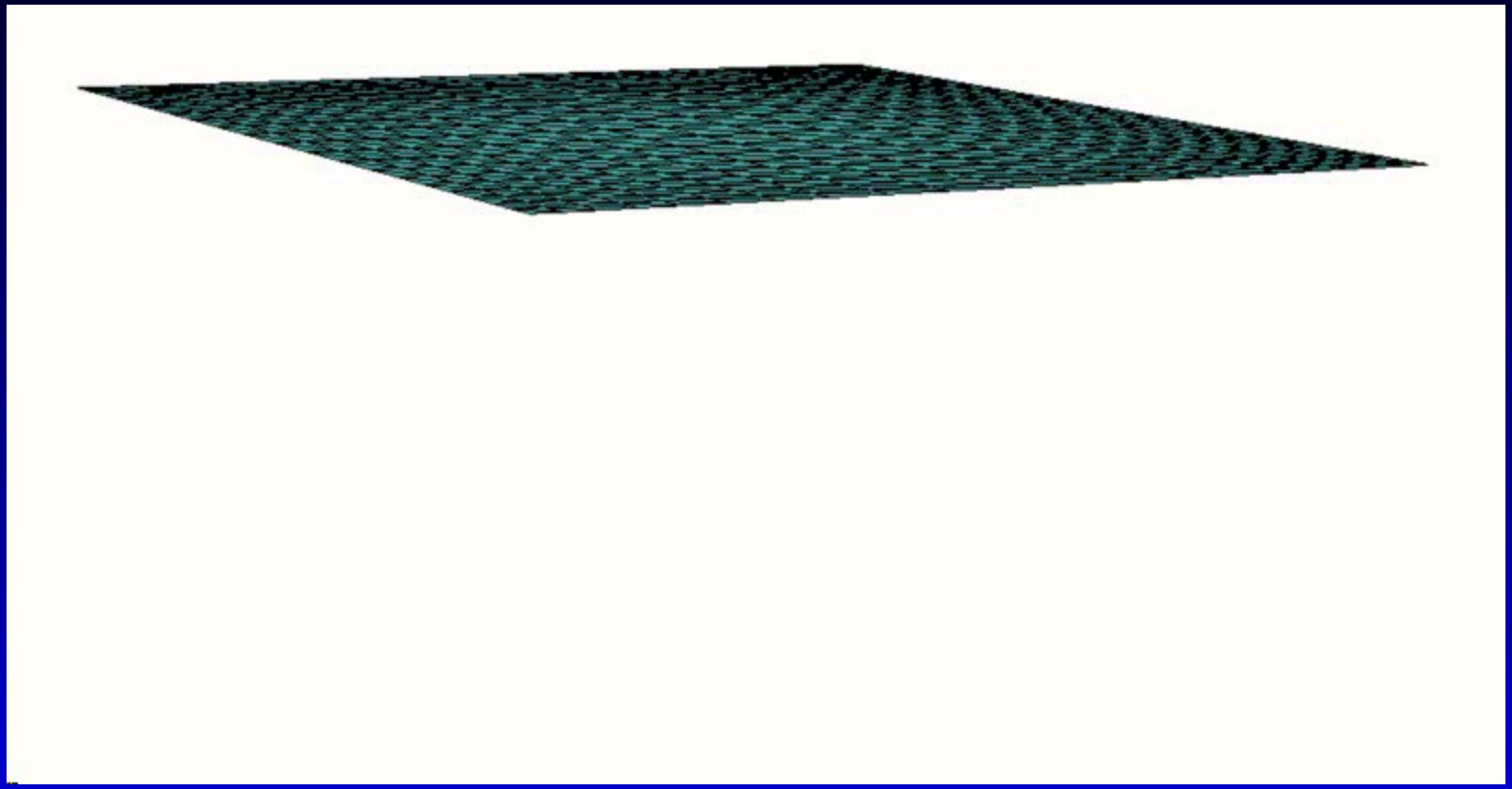
N-S Solver Examples



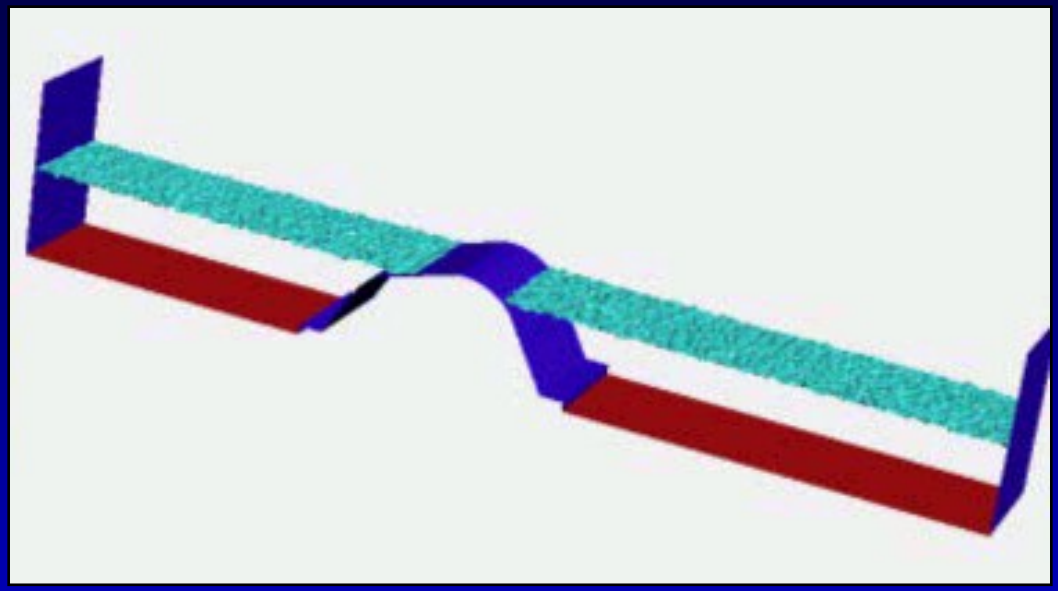
waterA.mov



Finite Element Fabric Model



N-S Solution for NBS



Conclusions

- Nearshore breakwater required for nearshore logistics
- Multi-tube fabric structure shows promise
- Navier-Stokes implementation will speed development
- Future work with modified geometry has begun